Fault Detection in Gears Using Fault Samples Enlarged by a Combination of Numerical Simulation and a Generative Adversarial Network

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Abstract

It is inevitable for gear to become damaged, which has a profound effect on the performance of gear transmission systems. Solving the problem of gear fault detection using artificial intelligence models depends on sufficient fault samples, though they might not always exist. A new method using numerical simulation and a generative adversarial network (GAN) is proposed to enlarge fault samples for detecting faults in gears. First, to supplement the missing fault samples, numerical simulation is employed to obtain simulation fault samples. Then, simulation and measurement fault samples are input into the GAN to generate synthetic fault samples to enlarge the training samples. Finally, the simulation, measurement and related synthetic fault samples serve as typical classifiers, including convolutional neural network, recurrent neural network, and stacked autoencoder, while the test samples of unknown faults are finally detected. Three experimental groups are designed to classify gear faults. The average classification accuracy is 100, 98.83, and 97.64%, which confirms the feasibility and effectiveness of the method for detecting gear faults using incomplete fault samples. The idea presented herein is expected to apply in any type of mechanical system that has the corresponding well-constructed numerical simulation model.